

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
27 November 2003 (27.11.2003)

PCT

(10) International Publication Number  
**WO 03/097382 A2**

- (51) International Patent Classification<sup>7</sup>: **B60C**
- (21) International Application Number: PCT/US03/15278
- (22) International Filing Date: 16 May 2003 (16.05.2003)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:  
10/146,933 17 May 2002 (17.05.2002) US  
10/224,435 21 August 2002 (21.08.2002) US
- (71) Applicant: **SIMULA, INC.** [US/US]; 2625 South Plaza Drive, Suite 100, Tempe, AZ 85282 (US).
- (72) Inventors: **SHILLIDAY, David**; 1717 E. Union Hills #2034, Phoenix, AZ 85024 (US). **SCAVEN, Gregory, J.**; 2037 E. Hermosa Vista Drive, Mesa, AZ 85213 (US). **FITZGERALD, Kevin**; 6604 E. Regina Street, Mesa, AZ 85204 (US).
- (74) Agents: **GOTTS, Lawrence et al.**; Shaw Pittman LLP, 1650 Tysons Boulevard, McLean, VA 22102-4859 (US).
- (81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZW.
- (84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).
- Published:**  
— *without international search report and to be republished upon receipt of that report*
- For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

WO 03/097382 A2

(54) Title: **DISTRIBUTED CHARGE INFLATOR SYSTEM**

(57) **Abstract:** An inflator includes a distributed charge to be distributed within an inflatable component of an inflatable system and a housing. The housing includes a combustion chamber and a gas storage chamber. The combustion chamber includes an initiator and a gas propellant. The gas storage chamber includes an inert gas at a high pressure. The housing also includes a gas nozzle. The distributed charge is connected to the housing through the gas nozzle. The distributed charge may be mechanically joined to the housing by a ferrule. Upon receiving an electrical signal from a crash sensor or other activator, the initiator ignites the gas propellant in the combustion chamber. The hot gas and hot particles from the burning gas propellant and the initiator flow into the gas storage chamber and heat the compressed inert gas in the gas storage chamber. The heated, compressed gas in the gas storage chamber flows through the gas nozzle and ignites the distributed charge. Combustion of the distributed charge generates a high volume of gas and inflates an inflatable component of an inflatable system.

## DISTRIBUTED CHARGE INFLATOR SYSTEM

[0001] This application is a continuation-in-part of U.S. Patent Application No. 10/146,933, filed May 17, 2002, which is herein incorporated by reference in its entirety.

### Field of the Invention

[0002] The present invention relates generally to the field of gas-generating devices for inflatable systems, and particularly to those used in inflatable restraint systems.

### Background of the Invention

[0003] Conventional inflators for inflatable systems, such as airbags, use either a highly pressurized stored gas or a propellant material, typically an azide-based gas generating material, that chemically reacts in a combustion reaction to produce gases.

[0004] However, the use of a stored, pressurized gas in an inflator is generally uneconomic because the pressure vessels required to store the gas are bulky, heavy and expensive and the use of gas-generating propellants produces significant quantities of toxic gases, such as carbon monoxide, and/or flammable gases, such as hydrogen.

[0005] Hybrid inflators utilize a combination of stored gas and the products of combustion of pyrotechnic material to deploy an inflatable system. The gas is stored in a chamber at a relatively high pressure. The chamber where the gas is stored is adjacent to a combustion chamber that contains an initiator and a pyrotechnic material for producing hot combustion gases that are delivered to the stored gas. The mixture of the hot combustion gases and stored gases are delivered through an outlet to inflate an inflatable component. Hybrid inflators are particularly useful in that no azide is required in the inflatable system and that complex filters are not required to cool and clean the gases. Examples of hybrid inflators are disclosed in U.S. Patent No. 5,670,738 (a hybrid inflator using compressed gas together with an initiator and a pyrotechnic gas generator), U.S. Patent, No. 5,660,412 (a hybrid inflator consisting of a pressure vessel containing a main charge of pyrotechnic material and a secondary charge of pyrotechnic material, wherein the secondary charge produces products of combustion that

ignite the main charge), U.S. Patent No. 5,588,676 (a hybrid inflator with a pyrotechnic gas generator and a gas chamber storing pressurized gas), U.S. Patent No. 5,462,307 (a hybrid airbag inflator with a first chamber containing compressed gas and a second chamber containing an igniter and pyrotechnic material) and U.S. Patent No. 5,131,680 (an inflator assembly which includes pyrotechnic material and a container of gas under pressure). Each of the above mentioned patent is incorporated herein by reference.

[0006] Distributed charge inflators generally include a distributed gas-generating material, that may have a faster burning center core ignition material surrounded by supplemental propellant, or use a homogenous mixture of ignition material and propellant, and also include an initiator (e.g., an electronic squib) used to ignite the gas generating material upon a signal from an initiating device. The fast burning gas generating material or "distributed charge" is designed to be installed within and distributed along the interior of the undeployed inflatable component itself. It is not necessary to contain the distributed charge within any type of exterior housing or assembly.

[0007] Figure 1 shows a distributed charge inflator installed within an inflatable system disclosed in U.S. Patent No. 6,062,143, which is assigned to the assignee of the present application and is incorporated herein by reference. As shown, inflatable system 4 includes a inflatable component 3 and a distributed charge inflator. The distributed charge inflator includes a distributed charge 14, a sheath 17 and an initiator 11. Distributed charge 14 is distributed within the inflatable component 3. Inflatable system 4 receives an electric signal from an activator 1 along a wire 2, when a crash sensor or other activator determines that the inflatable component must be deployed. Upon receiving a signal from a sensor, initiator 11 ignites distributed charge 14. The combustion of distributed charge 14 generates a gas and inflates an inflatable component 3.

[0008] Because the distributed charge is distributed, rather than confined to a small enclosed container or chamber as in the prior art systems listed above, it generates gases and releases the generated gases with far less explosive force than in the prior art systems. The distributed charge inflator system virtually eliminates the uneven inflations, pressure waves, and inertial effects of gases injected into the inflatable components from externally located gas generators.

Also, the distributed charge inflator equipped inflatable restraints deploy less aggressively than existing systems because the energy of the expanding gases is essentially distributed uniformly throughout the inflatable structure during deployment.

[0009] Further, because the distributed charge is distributed internally within the inflatable component, there is no necessity to reinforce the inflatable fabric or bladder material against pressure, heat and high velocity particulates at the point at which gases would have been forcefully injected into the inflatable component from the gas generator external to the inflatable component.

[0010] The distributed charge inflator is not limited to simply propagating the rapid ignition of other materials, the burning of which then produces the quantities of gas necessary to inflate a given structure. The distributed charge inflator system is a complete, autonomously-operating inflation system.

[0011] Example of inflatable components which the distributed charge inflator can be used to inflate are described in U.S. Patent No. 5,282,648 (body and head restraints); U.S. Patent No. 5,322,322 (side impact head strike protection); U.S. Patent No. 5,480,181 (side impact head strike protection); and U.S. Patent No. 5,464,246 (tubular cushions), which are incorporated herein by reference, as well as automotive airbags and other inflatable products.

#### **SUMMARY OF THE INVENTION**

[0012] The present invention is an improved distributed charge inflator system that can be used in conjunction with a wide variety of inflatable systems such as inflatable restraint systems, inflatable flotation systems, or passive inflatable safety systems.

[0013] The inflator is typically activated by an electronic sensor (for example, by an electronic crash sensor when the inflatable component is an airbag or other safety equipment which must be deployed in the event of a crash). However, the inflator may also be activated, for example, by another type of automatic device, or it may be activated by a mechanical device such as a button or switch or handle which is pushed, switched or pulled, respectively, by a user to deploy the inflatable component. For example, deployment of a life raft may be activated automatically by a sensor detecting immersion of the life raft in water, or it may be activated by a user pulling a handle. The device (crash sensor, mechanical

device, button, switch, handle, water sensor or other device) that activates the inflation of the system will be referred to herein as the "activator."

[0014] In an embodiment of the present invention, an inflator includes a distributed charge to be distributed within an inflatable component of an inflatable system and a housing. The housing includes a combustion chamber and a gas storage chamber. The combustion chamber includes an initiator and a gas propellant. The gas storage chamber includes an inert gas, such as argon, nitrogen or helium, at a high pressure. The housing also includes a gas nozzle. The gas storage chamber is in direct fluid communication with the distributed charge through the gas nozzle. The distributed charge may be mechanically joined to the housing by a ferrule.

[0015] Upon receiving an electrical signal from a crash sensor or other activator, the initiator ignites the gas propellant in the combustion chamber. The hot gas and hot particles from the burning gas propellant and the initiator flow into the gas storage chamber and heat the compressed inert gas in the gas storage chamber. The heated, compressed gas in the gas storage chamber flows through the gas nozzle and ignites the distributed charge. Combustion of the distributed charge generates a high volume of gas and inflates an inflatable component of an inflatable system.

[0016] In another embodiment of the present invention, an inflatable system includes an inflatable component with multiple inflatable chambers, a housing and multiple strands of distributed charge. Each of the multiple strands of distributed charge is distributed within each of the multiple inflatable chambers. The housing includes a combustion chamber and a gas storage chamber. The housing also includes a gas nozzle. The gas storage chamber is in direct fluid communication with the multiple strands of distributed charge through the gas nozzle. The multiple strands of distributed charge may be mechanically joined to the housing by a ferrule. Combustion of the each of the multiple strands of distributed charge generates a high volume of gas and inflates the each of the multiple inflatable chambers, thus forming an inflated component with multiple inflated chambers.

[0017] In another embodiment of the present invention, an inflator includes a distributed charge and a housing. The housing includes a combustion chamber and a gas storage chamber. The combustion chamber is in direct fluid

communication with the distributed charge through a gas nozzle. Upon receiving an electrical signal from a crash sensor or other activator, an initiator ignites a gas propellant in the combustion chamber and the distributed charge. Combustion of the distributed charge and the gas propellant generates a high volume of gas and inflates an inflatable component of an inflatable system. Simultaneously, the ignited gas propellant heats a compressed gas in the gas storage chamber. The heated, compressed gas in the gas storage chamber flows into the combustion chamber. The heated, compressed gas then flows through the gas nozzle and sustains the inflation of the inflatable component.

[0018] In another embodiment of the present invention, an inflatable system includes multiple strands of distributed charge and an inflatable component including multiple inflatable chambers. Each of the multiple strands of distributed charge is distributed within each of the multiple inflatable chambers of the inflatable component. The multiple strands of distributed charge are in direct fluid communication with a combustion chamber of a housing. The housing also includes a gas storage chamber. Upon receiving an electrical signal from a crash sensor or other activator, the initiator ignites a gas propellant in the combustion chamber and the multiple strands of the distributed charge. Combustion of the each of the multiple strands of distributed charge generates a high volume of gas and inflates the each of the multiple inflatable chambers of the inflatable component. Simultaneously, the ignited gas propellant in the combustion chamber heats a compressed gas in the gas storage chamber. The heated, compressed gas in the gas storage chamber flows into the combustion chamber. The heated, compressed gas then flows through the gas nozzle and sustains the inflation of the each of the multiple inflatable chambers of the inflatable component.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

[0019] Figure 1 is a schematic diagram of an inflatable system including an distributed charge inflator.

[0020] Figure 2 is a schematic diagram of an inflator according to an embodiment of the present invention.

[0021] Figure 3 is a schematic diagram of an inflatable system according to another embodiment of the present invention.

[0022] Figure 4 is a schematic diagram of an inflator according to another embodiment of the present invention.

[0023] Figure 5 is a schematic diagram of an inflatable system according to another embodiment of the present invention.

#### **DETAILED DESCRIPTION OF THE INVENTION**

[0024] Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings.

[0025] Figure 2 shows an inflator according to a preferred embodiment of the present invention.

[0026] As shown, inflator 200 includes a distributed charge 202 and a housing 204. Distributed charge 202 is designed to be installed within and distributed along the interior of the undeployed inflatable component of an inflatable system. Housing 204 includes a combustion chamber 210 and a gas storage chamber 220. Combustion chamber 210 includes an initiator 222, connector pins 224 and a gas propellant 226. Initiator 222 may be an electronic squib, such as the electronic squib used to initiate deployment of an automotive airbag. Connector pins 224 are used to electrically connect inflator 200 to a crash sensor or other activator. Gas propellant 226 may be pyrotechnic materials, such as boron potassium nitrate ( $\text{BKNO}_3$ ). Gas storage chamber 220 includes an inert gas, such as argon, nitrogen or helium, at pressure in the range of about 2000 to about 4000 psi. Housing 204 also includes a gas nozzle 230. Distributed charge 202 is connected to housing 204. Preferably, distributed charge 202 is connected to gas storage chamber 220 of housing 204 so that gas storage chamber 220 is in direct fluid communication with distributed charge 202 through gas nozzle 230. Distributed charge 202 may be mechanically joined to housing 204 by ferrule 250. Ferrule 250 also controls flow of the gas from gas storage chamber 220 to distributed charge 202.

[0027] Distributed charge 202 can be a solid monolithic rod of pyrotechnic materials formed into the desired configuration using binders. Optionally, distributed charge 202 can be enclosed in a sheath 203 (or layer or coating) for environmental protection. Inflator 200 can also include an end cap seal 216. End cap seal 216, for example, can be in the form of an o-ring, a gasket or other

appropriate form which serves to seal against moisture and contamination. End cap seal 216 can be made of rubber, RTV and/or metals.

[0028] The distributed charge may be a mixture of ammonium, guanidium, and/or triaminoguanidium salts of decahydrodecaboric acid and inorganic oxidizers such as ammonium nitrate and/or potassium nitrate. Representative compositions include about 5% to about 30% by weight of the decahydrodecaborate salt and about 70% to about 90% by weight of the nitrate salt. The additional materials may be used to coat, wrap, tape, or sheath the base distributed charge prior to installation of the overall distributed charge inflator in an inflatable system. The distributed charge may be an ITLX which is a simple, extruded product for linear ignition.

[0029] Alternatively, the distributed charge can include a core of ignition material and a sheath. Optionally, distributed charge may include a gas generating layer or coating. Ignition material is a moldable, formable, or extrudable rapidly burning pyrotechnic material, such as hydroborate fuel with various nitrate oxidizers (e.g., Rapid Deflagrating Cord (RDC) manufactured by Teledyne McCormick-Selph, Inc.), or secondary explosives loaded into a metal sheath (e.g., Mild Detonating Fuse (MDF), also known as Low Energy Detonating Cord or LEDC, manufactured by the Ensign Bickford Company of Simsbury, Conn.), as disclosed in the U.S. Patent No. 6,062,143, which is incorporated herein by reference.

[0030] Materials for the optional gas-generating layer or coating include alkali metal azides and organic azides with polymer binders, oxidizers, and metals used as the coating sheath or binder. For example, one possible composition for a particular application might be a mixture of about 20% to about 50% by weight sodium azide, about 25% to about 35% by weight of potassium nitrate, about 10% to about 15% by weight of a fluoroelastomer binder, and about 15% to about 25% by weight of magnesium.

[0031] Optionally, energetic propellants and explosives can also be added to the distributed charge composition or to the coating or wrapping. For example, butanetriol trinitrate (BTTN), pentaerythritol tetranitrate (PETN), cyclotrimethylene trinitramine (RDX), cycloteramethylene tetranitramine (HMX), metriol trinitrate (MTN), trinitrotoluene, nitroglycerine, or inorganic oxidizers,



hexanitrostilbene (HNS), dipicramid (DIPAM), or inorganic oxidizers such as potassium nitrate, with metals such as magnesium can be used.

[0032] Polymer binders which may be used to bind the distributed charge include: fluoroelastomers, crosslinked polybutadiene rubber, crosslinked polyacrylic rubber, crosslinked polyurethane elastomers, and polyvinyl alcohol/acetate. Energetic or gas-generating polymers which may be employed in the distributed charge assembly include: glycidyl nitrate polymers, glycidyl azide polymer, polytetrazoles, polytriazoles, nitrocellulose, dinitropolystyrene, nitrated polybutadienes, and nitrated polyethers.

[0033] The environmentally-sealed sheath enclosing the distributed charge may be fabricated from ductile, easily extrudable metals such as tin (preferably) or silver, antimony or copper, or plastics such as polyethylene, polyurethane elastomer or fluoroelastomers. The sheath is designed to encapsulate and protect the energetic gas-generating materials to allow uniform vaporization or burning. The sheath splits open or vaporizes following the ignition of the distributed charge. The distributed charge, the gas generating layer, and the sheath can be formed into a wide variety of shapes and sizes to suit the specific application.

[0034] Inflator 200 receives an electric signal when a crash sensor or other activator determines that the inflatable component must be deployed. Upon receiving the electrical signal, initiator 222 ignites gas propellant 226 in combustion chamber 210. As pressure in combustion chamber 210 rises and exceeds the pressure of gas storage chamber 220, hot gas and hot particles from the burning gas propellant and the initiator flow into gas storage chamber 220. The hot gas and hot particles from combustion chamber 210 heat the compressed inert gas and cause a rapid pressure rise in gas storage chamber 220. The heated, compressed gas in gas storage chamber 220 flows through gas nozzle 230 and ignites distributed charge 202. Combustion of distributed charge 202 generates a high volume of gas which inflates an inflatable component of an inflatable system, such as an airbag.

[0035] The distributed charge may be manufactured in various sizes and configurations, depending upon the inflation requirements of the system for which it is intended. These may range from a foil or thin film, or linear or tubular shaped charges to broad flat sheets of distributed charge material which may be

cut, trimmed, or otherwise fitted. The distributed charge material, whether in a linear or sheet form, may, in cross-section, be circular, wedge-shaped, diamond-shaped, "L" shaped, or formed in any number of other configurations. Because of this flexibility and the inherent simplicity of the invention, the distributed charge inflator is easier to install and less expensive to manufacture than gas generator systems currently in use.

[0036] The distributed charge inflator can be designed so that, depending on the pattern of distribution of the distributed charge within a given inflatable system, the rate at which different distributed charge sections are ignited, and the number or location of the electronic squib used to ignite the material, variable inflation rates and effective total gas volumes may be achieved. The materials used for the distributed charge should be flexible and pliable, such that they will not fracture or flow under normal operating conditions.

[0037] Figure 3 shows an inflatable system according to another preferred embodiment of the present invention.

[0038] As shown, inflatable system 300 includes an inflatable component 340, a housing 304 and multiple strands of distributed charge 302A, 302B and 302C. Inflatable component 340 includes multiple inflatable chambers 340A, 340B and 340C. Each of the multiple strands of distributed charge 302A, 302B and 302C is distributed within each of the multiple inflatable chambers 340A, 340B and 340C, respectively. Housing 304 includes a combustion chamber 310 and a gas storage chamber 320. Combustion chamber 310 includes an initiator 322, connector pins 324 and a gas propellant 326. Gas storage chamber 320 includes an inert gas at a high pressure. Housing 304 also includes a gas nozzle 330. The multiple strands of distributed charge are connected to housing 304. Preferably, multiple strands of distributed charge are connected to gas storage chamber 320 of housing 304 so that gas storage chamber 320 is in direct fluid communication with the multiple strands of distributed charge through gas nozzle 330. The multiple strands of distributed charge may be mechanically joined to housing 304 by a ferrule 350.

[0039] Upon receiving an electrical signal from a crash sensor or other activator, initiator 322 ignites gas propellant 326 in combustion chamber 310. The hot gas and hot particles from the burning gas propellant and the initiator flow into gas storage chamber 320 and heat the compressed inert gas in gas storage chamber

320. The heated, compressed gas in gas storage chamber 320 flows through gas nozzle 330 and ignites multiple strands of distributed charge 302A, 302B and 302C. Combustion of each of the multiple strands of distributed charge 302A, 302B and 302C generates a high volume of gas and inflates each of the multiple inflatable chamber 340C, 340B and 340C, respectively, thus forming an inflated component with multiple inflated chambers.

[0040] Figure 4 shows an inflator according to another preferred embodiment of the present invention.

[0041] As shown, inflator 400 includes a housing 404 and a distributed charge 402. Housing 404 includes a combustion chamber 410 and a gas storage chamber 420. Combustion chamber 410 includes an initiator 422, connector pins 424 and a gas propellant 426. Gas storage chamber 420 includes an inert gas at a high pressure. Housing 404 also includes a gas nozzle 430. Distributed charge 402 is connected to housing 404. Preferably, distributed charge 402 is connected to combustion chamber 410 of housing 404 so that combustion chamber 410 is in direct fluid communication with distributed charge 402 through gas nozzle 430. Optionally, distributed charge 402 may be directly connected to initiator 422 in combustion chamber 410. Distributed charge 402 may be mechanically joined to housing 404 by a ferrule 450.

[0042] Upon receiving an electrical signal from a crash sensor or other activator, initiator 422 ignites gas propellant 426 in combustion chamber 410 and distributed charge 402, causing the inflation of an inflatable component, such as an airbag. Simultaneously, the hot gas and hot particles from the burning gas propellant and the initiator flow into gas storage chamber 420. The hot gas and hot particles from combustion chamber 410 heat the compressed inert gas and cause a rapid pressure rise in gas storage chamber 420. The heated, compressed gas in gas storage chamber 420 flows into combustion chamber 410 and through gas nozzle 430. The heated, compressed gas sustains the inflation of the inflatable component.

[0043] Figure 5 shows an inflatable system according to yet another preferred embodiment of the present invention.

[0044] As shown, inflatable system 500 includes an inflatable component 540, a housing 504 and multiple strands of distributed charge 502A, 502B and 502C.

Inflatable component 540 includes multiple inflatable chambers 540A, 540B and 540C. Each of the multiple strands of distributed charge 502A, 502B and 502C is distributed within each of the multiple inflatable chambers 540A, 540B and 540C, respectively. Housing 504 includes a combustion chamber 510 and a gas storage chamber 520. Combustion chamber 510 includes an initiator 522, connector pins 524 and a gas propellant 526. Gas storage chamber 520 includes an inert gas at a high pressure. Housing 504 also includes a gas nozzle 530. The multiple strands of distributed charge are connected to housing 504. Preferably, the multiple strands of distributed charge are connected to combustion chamber 510 of housing 504 so that combustion chamber 510 is in direct fluid communication with the multiple strands of distributed charge through the gas nozzle. Optionally, the multiple strands of distributed charge may be directly connected to initiator 522 in combustion chamber 510. Multiple strands of distributed charge 502A, 502B and 502C are mechanically joined to housing 504 by a ferrule 550. Upon receiving an electrical signal from a crash sensor or other activator, initiator 522 ignites gas propellant 526 in combustion chamber 510 and multiple strands of distributed charge 502A, 502B and 502C, thus forming an inflated component with multiple inflated chambers. Simultaneously, the hot gas and hot particles from the burning gas propellant and the initiator flow into gas storage chamber 520 and heat the compressed inert gas in gas storage chamber 520. The heated, compressed gas in gas storage chamber 520 flows into combustion chamber 510 and flows through gas nozzle 530. The heated, compressed gas from gas storage chamber 520 sustains the inflation of the multiple inflatable chambers.

[0045] The inflator in the present invention uses a distributed charge with a combination of pyrotechnic and stored gas. Alternatively, conventional compressed-gas inflator can be used with a distributed charge.

[0046] The foregoing disclosure of the preferred embodiments of the present invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Many variations and modifications of the embodiments described herein will be apparent to one of ordinary skill in the art in light of the above disclosure. The scope of the invention is to be defined only by the claims appended hereto, and by their equivalents.

**WHAT IS CLAIMED IS:**

1. An inflatable system comprising:  
an inflatable component;  
a charge distributed within the inflatable component for generating inflating gas; and  
a housing including a first chamber and a second chamber in communication with the first chamber,  
wherein the first chamber includes an initiator and a gas propellant, and the second chamber includes a compressed gas, wherein the charge is connected to the housing.
2. The system of claim 1, wherein the charge is connected to the first chamber.
3. The system of claim 1, wherein the charge is connected to the second chamber.
4. The system of claim 1, wherein the charge is connected to the initiator.
5. The system of claim 1, wherein the initiator ignites the gas propellant and the charge.
6. The system of claim 1, wherein the initiator ignites the gas propellant in the first chamber and the ignited gas propellant heats the compressed gas in the second chamber.
7. The system of claim 6, wherein the heated, compressed gas sustains an inflation of the inflatable component.
8. The system of claim 6, wherein the heated compressed gas ignites the charge.
9. The system of claim 1, wherein the charge is enclosed in a sheath.
10. The system of claim 1, wherein the charge is made of a rod of pyrotechnic materials.
11. The system of claim 1, wherein the system includes a plurality of charges distributed within the inflatable component for generating inflating gas.
12. The system of claim 11, wherein the plurality of charges are connected to the first chamber.
13. The system of claim 11, wherein the plurality of charges are connected to the second chamber.
14. The system of claim 11, wherein the inflatable component includes a plurality of inflatable chambers.
15. The system of claim 14, wherein each of the plurality of charges is distributed within one of each of the plurality of inflatable chambers.
16. The system of claim 1, wherein the charge is mechanically joined to the housing by a ferrule.

17. An inflatable system comprising:
  - an inflatable component;
  - a charge distributed within the inflatable component for generating inflating gas;
  - a first chamber including an initiator and a gas propellant; and
  - a second chamber in communication with the first chamber, including a compressed gas, wherein the charge is in direct fluid communication with the first chamber.
18. The system of claim 17, wherein the charge is enclosed in a sheath.
19. The system of claim 17, wherein the charge is made of a rod of pyrotechnic materials.
20. The system of claim 17, wherein the system includes a plurality of charges distributed within the inflatable component for generating inflating gas.
21. The system of claim 20, wherein the inflatable component includes a plurality of inflatable chambers.
22. The system of claim 21, wherein each of the plurality of charges is distributed within one of each of the plurality of inflatable chambers.
23. An inflatable system comprising:
  - an inflatable component;
  - a charge distributed within the inflatable component for generating inflating gas;
  - a first chamber including an initiator and a gas propellant; and
  - a second chamber in communication with the first chamber, including a compressed gas, wherein the charge is in direct fluid communication with the second chamber.
24. The system of claim 23, wherein ignition of the charge and the gas propellant inflates the inflatable component and heats the compressed gas, and then the heated compressed gas sustains the inflation of the inflatable component.
25. The system of claim 23, wherein the system includes a plurality of charges distributed within the inflatable component for generating inflating gas.
26. The system of claim 25, wherein the inflatable component includes a plurality of inflatable chambers.
27. The system of claim 26, wherein each of the plurality of charges is distributed within one of each of the plurality of inflatable chambers.
28. An inflatable system comprising:
  - an inflatable component including a plurality of inflatable chambers;
  - a plurality of charges for generating inflating gas; and

a housing connected to the plurality of charges, including an initiator,  
wherein each of the plurality of charges is distributed in one of each of the plurality of inflatable chambers.

29. The system of claim 28, wherein the each of the plurality of charges inflates the one of each of the plurality of inflatable chamber.

30. The system of claim 28, wherein the housing includes a first chamber including an initiator and a gas propellant, and the second chamber including a compressed gas.

31. The system of claim 30, wherein the plurality of charges are connected to the first chamber.

32. The system of claim 30, wherein the plurality of charges are connected to the second chamber.

33. The system of claim 30, wherein the plurality of charges are connected to the initiator.

34. An inflatable system comprising:

an inflatable component;

a charge to be distributed within the inflatable component for generating inflating gas;

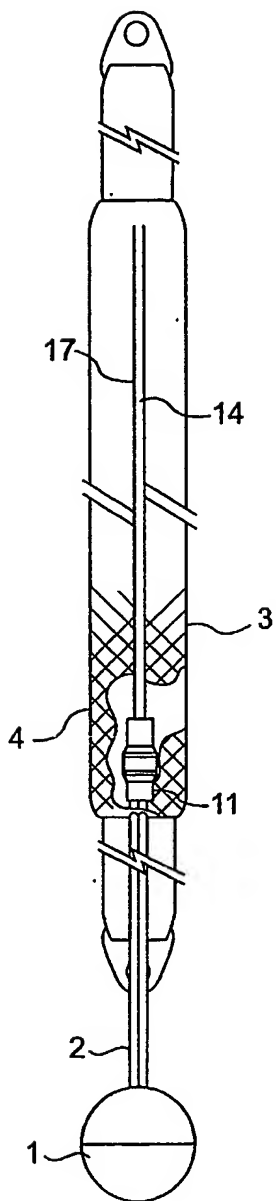
and

a housing including a first chamber and a second chamber,

wherein the first chamber includes an initiator and a gas propellant, and the second chamber includes an inert gas and a gas nozzle, wherein the charge is connected to the housing through the gas nozzle, wherein upon receiving an electrical signal from an activator, the initiator ignites the gas propellant in the first chamber, and then the ignited gas propellant flows into the second chamber and heat the inert gas in the second chamber, and then the heated inert gas in the second chamber flows through the gas nozzle and ignites the charge to inflate the inflatable component.

35. The system of claim 34, wherein the charge is mechanically joined to the housing by a ferrule.

1/5



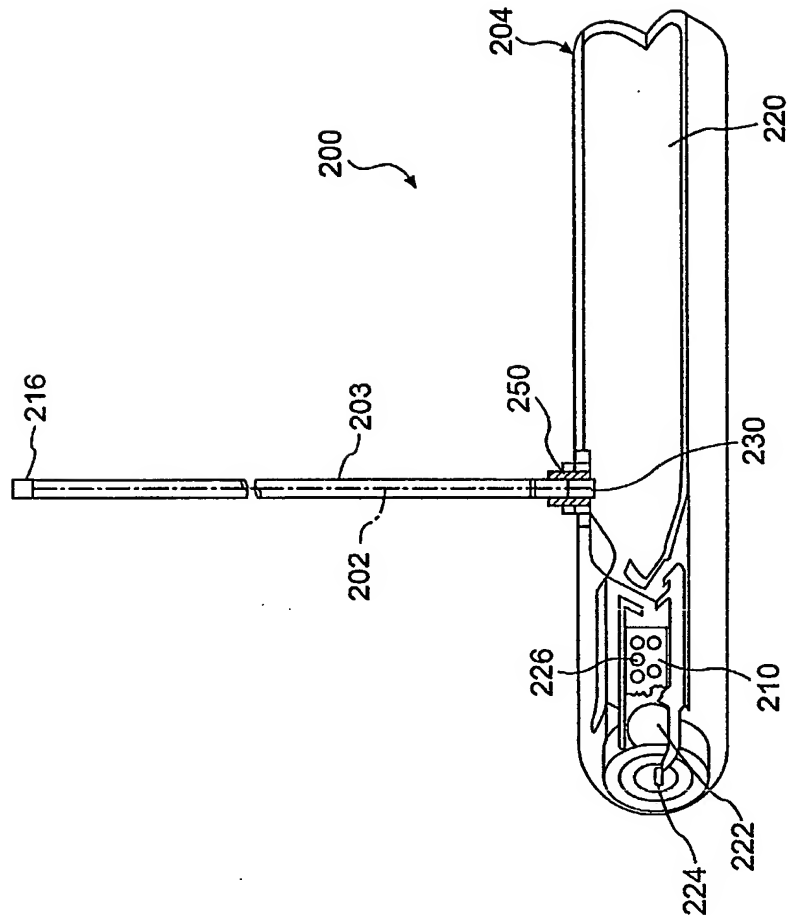
**FIG. 1**

SUBSTITUTE SHEET (RULE 26)

BEST AVAILABLE COPY



2/5

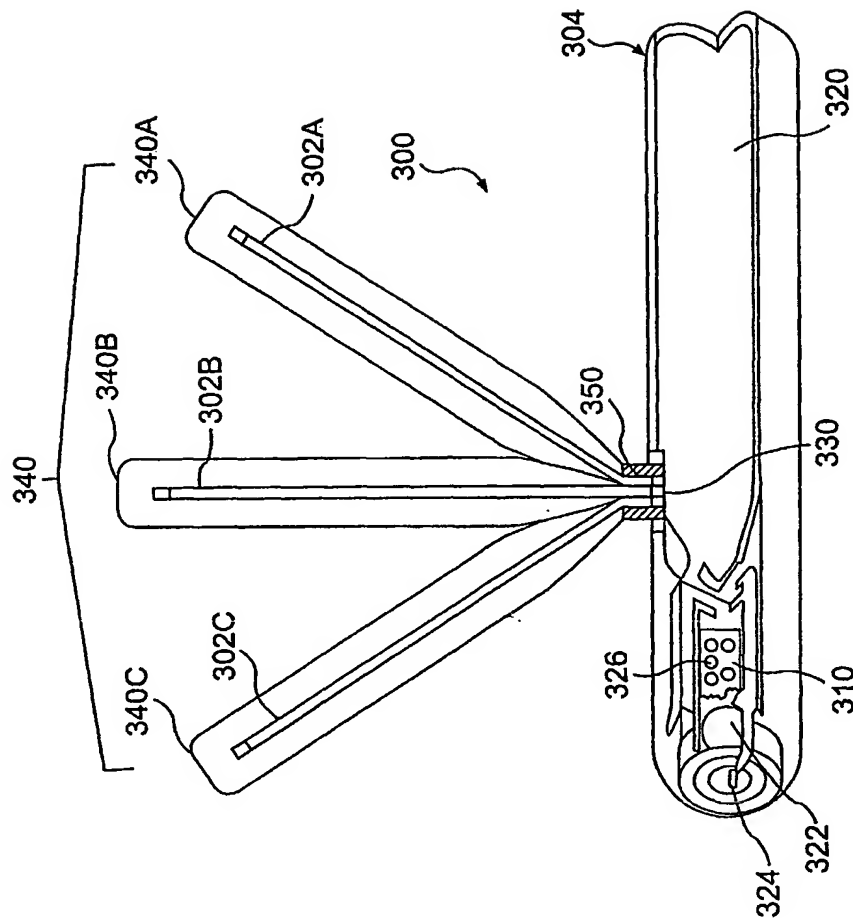


**FIG. 2**

SUBSTITUTE SHEET (RULE 26)

BEST AVAILABLE COPY

3/5

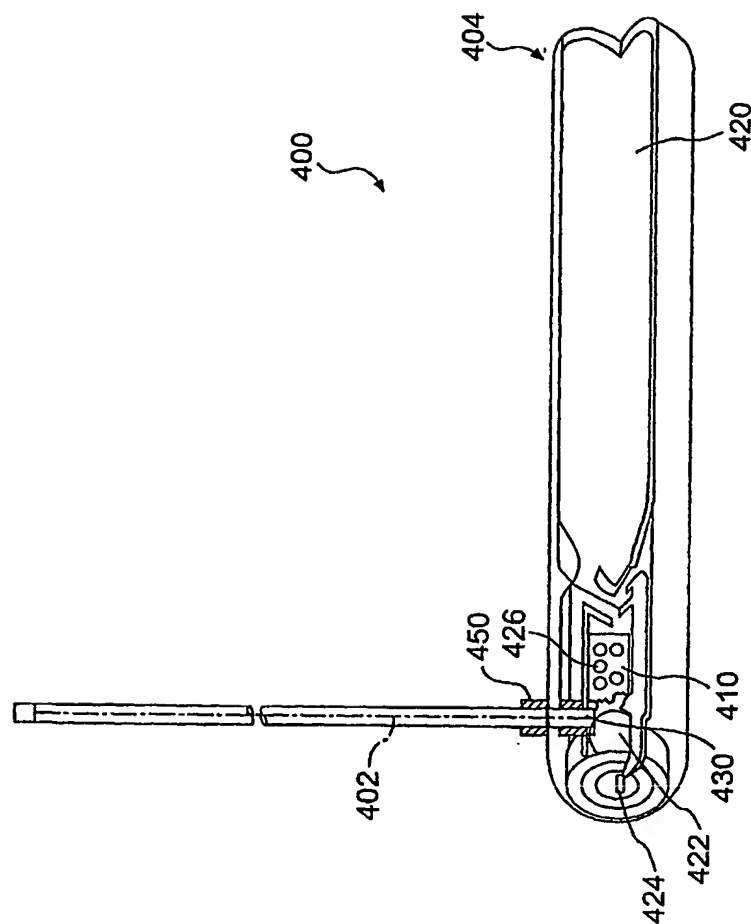


**FIG. 3**

SUBSTITUTE SHEET (RULE 26)

BEST AVAILABLE COPY

4/5

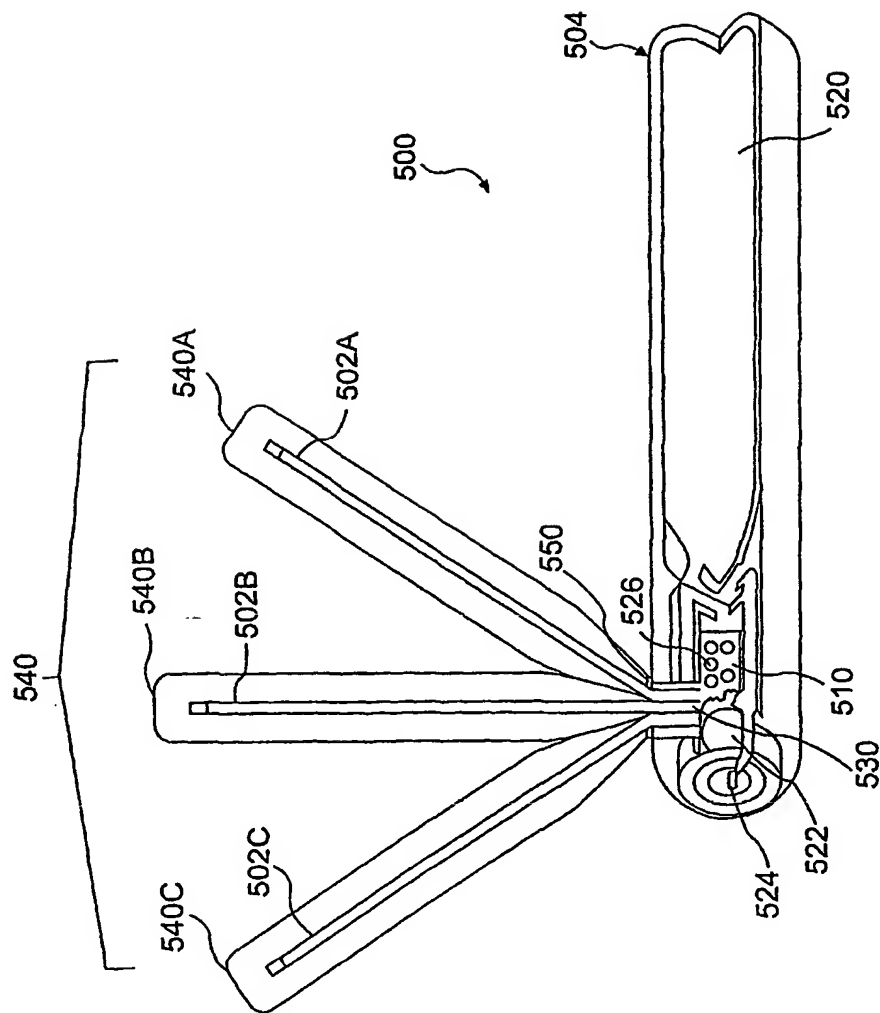


**FIG. 4**

SUBSTITUTE SHEET (RULE 26)

BEST AVAILABLE COPY

5/5



**FIG. 5**

SUBSTITUTE SHEET (RULE 26)

BEST AVAILABLE COPY